REMARKS

I. Summary of the Invention

The invention relates generally to a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members. (Specification, page 2, lines 8 to 11.) In particular, it is desired to make a proper metal-to-metal seal in a pipe connector of the kind that forms a pressure seal by wedging a metal seal ring between two hubs, and to permit the metal-to-metal seal to be broken and later properly reset. (Specification, page 2, lines 17 to 20 and page 3, lines 6 to 10.)

To solve these problems, there is provided a composite metal seal (15) that includes a core (34) of relatively hard metal, and at least one annular region (35, 36) of relatively soft metal. The annular region of relatively soft metal is integrally bonded with the core of relatively hard metal, and has an annular sealing surface (32, 33) for providing a fluid pressure seal. (Specification, page 4, lines 19 to 24; page 13 line 23 to page 14 line 10; FIG. 3.) In the preferred construction, the annular region of relatively soft metal 35, 36 is welded onto the relatively hard metal core 14. (Specification, page 17, lines 8 to 16; FIG. 6.)

The applicant's invention provides a number of advantages. The composite metal seal ring 15 functions as an integral piece of metal, although the properties of the metal are different in different regions of the composite metal seal ring. (Specification, page 17, lines 13 to 16.) The soft overlay metal can flow into any discontinuity that may exist in the hub seal surfaces and effect a seal. Moreover, the soft overlay metal will not scratch or impinge the hub sealing surfaces. (Specification, page 14, lines 7 to 10.) The hard metal core 34 ensures that there can be a relatively high contact stress between the metal seal ring 15 and the hub sealing surfaces. The high compressive stress in the seal enhances the seal's ability to withstand any external

pressure, and internal pressure further energizes the seal. By overlaying a high strength core, the high strength capacity of the seal is maintained and a softer exterior surface is presented that will deform prior to deformation of the hub surfaces. Therefore, the hard metal core 34 ensures that the seal ring can be used after making and breaking the metal seal numerous times.

(Specification, page 14, lines 11 to 21.)

II. Issues

A. Is it proper to interpret "integrally bonded" to mean merely that the hard and soft metal of the composite metal seal ring are held next to each other or are in contact?

B. It is proper to modify Fyffe U.S. 1,426,724 in view of Bloom 5,680,495 so as to reconstruct the applicant's claimed invention?

ARGUMENT

A. It is improper to interpret "integrally bonded" to mean merely that the hard and soft metal of the composite metal seal ring are held next to each other or are in contact.

Paragraph 9 on page 7 of the Final Official Action says: "Argument concerning integrally bonded in not persuasive because integrally bonded interpreted broadly can mean that the hard and soft metal of the composite metal seal ring are held next to each other or are in contact." Applicant respectfully disagrees. Such an interpretation is an unreasonably broad interpretation.

According to the Manual of Patent Examining Procedure, Section 2111:

> The broadest reasonable interpretation of the claims must also be consistent with the interpretation that those skilled in the art would reach. In re Cortright, 165 F.3d 1353, 1359, 49 USPQ2d 1464, 1468 (Fed. Cir. 1999)(The Board's construction of the claim limitation "restore hair growth" as requiring the hair to be returned to its original state was held to be an unreasonably broad interpretation of the limitation. The court held that, consistent with applicant's disclosure and the disclosure of three patents from analogous arts using the same phrase to require only some increase in hair growth, one of ordinary skill would construe "restore hair growth" to mean that the claimed method increases the amount of hair grown on the scalp, but does not necessarily produce a full head of hair.)

The specification as originally filed, page 17, lines 8 to 16, uses the term "integral bond" in the following fashion:

> A preferred method of fabricating the composite metal seal ring 15 includes a welding overlay process. This welding process deposits the relatively soft metal overlay 35, 36 onto the relatively hard metal core 34 in such a way as to produce an integral bond between them. <u>In other words, the composite metal seal ring 15 functions as an integral piece of metal</u>, although the properties of the metal are different in different regions of the composite metal seal ring. (Emphasis added.)

The applicants' usage of the term "integral bond" is consistent with the common meaning of the terms "integral" and 'bond" and therefore must be given legal effect. See, for example, the enclosed pages 168 and 738 from <u>Webster's Encyclopedic Unabridged Dictionary of the English Language, Random House, New York, New York, 1989</u>. The applicable definition of "bond" includes "14: adhesion between two substances or objects." The applicable definition of "integral" includes "3: made up of parts which together constitute a whole."

See also M.P.E.P. 2111.01:

> APPLICANT MAY BE OWN LEXICOGRAPHER
>
> Applicant may be his or her own lexicographer as long as the meaning assigned to the term is not repugnant to the term's well known usage. In re Hill, 161 F.2d 367, 73 USPQ 482 (CCPA 1947). Any special meaning assigned to a term "must be sufficiently clear in the specification that any departure from common usage would be so understood by a person of experience in the field of the invention." Multiform Desiccants Inc. v. Medzam Ltd., 133 F.3d 1473, 1477, 45 USPQ2d 1429, 1432 (Fed. Cir. 1998).

A hard metal object and a soft metal object merely held next to each other or in contact with each other do not have adhesion between them, and the two objects do not constitute a whole. Such a pair of metal objects do not function as an integral piece of metal, as required by the applicant's specification. The definition of "integral bond" proposed in the Final Official Action is inconsistent with the usage of the term in the applicant's specification. It renders the word "integral" meaningless. It is inconsistent with the interpretation that those skilled in the art would reach. Therefore, such an interpretation is an unreasonably broad interpretation.

B. It is improper to modify Fyffe U.S. 1,426,724 in view of Bloom 5,680,495 so as to reconstruct the applicant's claimed invention.

The Final Official Action, paragraph 5 on page 5, relies on Bloom for showing "a deformable metal seal (70), where a soft metal is welded onto a relatively hard metal (metal layer 76 and 78)." However, Bloom describes (70) as "a deformable metal layer " that "comprises a first layer 76 and a second layer 78" and that are "overlaying the [substrate] body 74." (Bloom, col. 6, lines 26-29.) In other words, the layers 76 and 78 are layers on a substrate body 74, and

two substrate bodies are bonded together to hermetically seal a fiber optic device. (See the abstract and FIG. 9.) Moreover, there is nothing in Bloom disclosing that the inner metal layer 76 is a relatively hard metal layer, and the outer metal layer 78 is a relatively soft metal layer. For example, the inner metal layer 76 consists essentially of pure aluminum, and the outer metal layer 78 consists essentially of gold. (Bloom, col. 6, lines 33-35.) One would expect pure aluminum and pure gold to have similar hardness, but essentially pure aluminum may be softer than essentially gold. See also the enclosed two pages 28-43 and 28-48 from Perry's Chemical Engineer's Handbook, Seventh Edition, McGraw-Hill, 1997, disclosing a hardness of 19 for min 99.6% pure aluminum AA designation 1060 (right-hand column of Table 28-16) and a hardness of 25 for min 99.95 % annealed gold designation UNS P00020 (right-hand column in Table 28-19). In this case, a harder metal layer (essentially gold) would be overlaid on a softer metal layer (essentially pure aluminum). Moreover, Bloom Col. 6 lines 61-62 appears to refer to the ultrasonic welding of contacting outer metal layers 70 at the complementary middle regions 72, creating a hermetic seal between the substrates 64a and 64b along the middle surface 72. (Bloom, col. 6, lines 49-56.) Furthermore, the very thin metal layers in the miniature electronic device of Bloom are not analogous to the hard and soft metal regions of the applicant's claimed invention.

In paragraph 5, on page 5, the Final Official Action concludes: "It would have been obvious to one having ordinary skill in the art at the time of the invention was made to have the relatively hard metal and the relatively soft metal of Fyffe to be welded to each other, to provide a hermetic seal and gas tight seal (a seal having metal layers 76 and 78 to be bonded by welding, column 6, lines 17-23, lines 31-28, lines 51-53 and 60-63)." However, it is not seen how the advantage of hermetic sealing of a miniature solid-state electronic device would provide a proper

motivation for modifying the pipe joint seal of Fyffe, nor would the proposed application of the teaching of hermetic sealing to a pipe joint result in applicant's claimed invention. It is not evident from the cited references where Fyffe is deficient in its intended purpose of making a pipe connection that is not necessarily permanent. Moreover, if one wants to hermetically seal a joint between metal pipes, in accordance with the proposed teaching of Bloom, it is not seen why one would deviate from the common practice of simply welding the pipes to each other.

The policy of the Patent and Trademark Office has been to follow in each and every case the standard of patentability enunciated by the Supreme Court in Graham v. John Deere Co., 148 U.S.P.Q. 459 (1966). M.P.E.P. § 2141. As stated by the Supreme Court:

> Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy.

148 U.S.P.Q. at 467.

The problem that the inventor is trying to solve must be considered in determining whether or not the invention would have been obvious. The invention as a whole embraces the structure, properties and problems it solves. In re Wright, 848 F.2d 1216, 1219, 6 U.S.P.Q.2d 1959, 1961 (Fed. Cir. 1988).

For the teachings of a reference to be prior art under 35 U.S.C. §103, there must be some basis for concluding that the reference would have been considered by one skilled in the particular art working on the particular problem with which the invention pertains. In re Horne, 203 U.S.P.Q. 969, 971 (C.C.P.A. 1979). Non-analogous art cannot properly be pertinent prior art under 35 U.S.C.

§103. In re Pagliaro, 210 U.S.P.Q. 888, 892 (C.C.P.A. 1981). The determination of whether a reference is from a non-analogous art is a two-step test as set forth in Union Carbide Corp. v. American Can Co., 724 F.2d 1567, 1572, 220 U.S.P.Q. 584, 588 (Fed. Cir. 1984). In Union Carbide, the court found that the first determination was whether "the reference is within the field of the inventor's endeavor." If it is not, one must proceed to the second step "to determine whether the reference is reasonably pertinent to the particular problem with which the inventor was involved." Id. "[T]he purposes of both the invention and the prior art are important in determining whether the reference is reasonably pertinent to the problem the invention attempts to solve." In re Clay, 966 F.2d 656, 659, 23 U.S.P.Q.2d 1058, 1061 (Fed. Cir. 1992).

In the present case, the applicant's invention is directed to a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members. Fyffe is in the applicant's field of endeavor, but Bloom is not. For example, Bloom is classified in class 385 (Optical Waveguides), and Bloom's field of search further includes class 372 (Coherent Light Generators), class 257 (Active solid-state devices, e.g., transistors, solid-state diodes), and class 437 [438? (Semiconductor device manufacturing: process)].

Bloom is not reasonably pertinent to the particular problem with which the inventor was involved. Among other things, Bloom is directed to sealing a fiber optic device by compressed metal seals; in other words, encapsulating and sealing a miniature solid-state electronic device from the surrounding environment. This is not reasonably pertinent to the applicant's problem of improving a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members in order to permit the metal-to-metal seal to be broken and later properly reset. There is no basis for concluding that Bloom would have

been considered by one skilled in the pipe seal art working on the particular problem with which the applicant's invention pertains.

Even if there would be some basis for concluding that a person of ordinary skill in the art would have considered Bloom, there is nothing in the prior art as a whole suggesting the desirability of modifying Fyffe in view of Bloom. Fyffe appears to be entirely satisfactory for its intended purpose of providing a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members in order to permit the metal-to-metal seal to be broken and later properly reset. Bloom relates to hermetically sealing a miniature solid-state electronic device from its surrounding environment. If a person of ordinary skill in the pipe seal art would be told to apply a teaching from Bloom to provide a hermetic and gas tight pipe seal by welding, it is not seen why the person of ordinary skill in the pipe seal art would deviate from the common practice of simply welding the pipes to each other.

It appears that the only motivation for modifying Fyffe to arrive at the applicant's invention is the applicant's own novel disclosure of welding a relatively soft annular metal overlay onto a relatively hard metal core. However, it is improper to attempt to establish obviousness by using the applicant's specification as a guide to combining different prior art references to achieve the results of the claimed invention. Orthopedic Equipment Co., Inc. v. United States, 702 F.2d 1005, 1012, 217 U.S.P.Q. 193, 199 (Fed. Cir. 1983). Hindsight reconstruction, using the applicant's specification itself as a guide, is improper because it fails to consider the subject matter of the invention "as a whole" and fails to consider the invention as of the date at which the invention was made. The critical inquiry is whether there is something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination. In re Dembiczak, 175 F.3d 994, 999-1000, 50 U.S.P.Q.2d 1614, 1617 (Fed. Cir. 1999)(actual evidence and particular findings

need to support the PTO's obviousness conclusion); Interconnect Planning Corp. v. Feil, 774 F.2d 1132, 1138, 227 U.S.P.Q. 543, 547 (Fed. Cir. 1985) ("The invention must be viewed not with the blueprint drawn by the inventor, but in the state of the art that existed at the time."); In re Fritch, 972 F.2d 1260, 1266, 23 U.S.P.Q.2d 1780, 1784 (Fed. Cir. 1992)("It is impermissible to use the claimed invention as an instruction manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious."); Fromson v. Advance Offset Plate, Inc., 755 F.2d 1549, 1556, 225 U.S.P.Q. 26, 31 (Fed. Cir. 1985) (nothing of record plainly indicated that it would have been obvious to combine previously separate lithography steps into one process). See, for example, In re Gordon et al., 733 F.2d 900, 902, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984) (mere fact that prior art could be modified by turning apparatus upside down does not make modification obvious unless prior art suggests desirability of modification); Ex Parte Kaiser, 194 U.S.P.Q. 47, 48 (PTO Bd. of Appeals 1975) (Examiner's failure to indicate anywhere in the record his reason for finding alteration of reference to be obvious militates against rejection).

In short, annular seals for coupling metal tubular members as in Fyffe, and welding techniques for joining metal tubular members, have been known for about 80 years since Fyffe, yet none of the art cited by the examiner applicable to annular seals suggests the applicant's invention, which admittedly offers significant advantages over the prior art. This is objective evidence of the patentability of the applicant's invention. Fromson v. Advance Offset Plate, Inc., 755 F.2d 1549, 1557, 225 U.S.P.Q. 26, 32-33 (Fed. Cir. 1985) (It is at best bizarre to assert that the subject matter claimed was merely an obvious extension of technology when none skilled in the art attempted such "extension" during the seven years when alleged economic advantages of such technology were available).

In view of the above, it is respectfully submitted that the application is in condition for allowance. Early allowance is earnestly solicited.

Respectfully submitted,

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APPENDIX I. VERSION WITH MARKINGS TO SHOW CHANGES MADE

4. (Once Amended) [The composite metal seal as claimed in claim 1] A composite metal seal comprising a core of relatively hard metal, and at least one annular region of relatively soft metal that is integrally bonded with the core of relatively hard metal and that provides an annular sealing surface for effecting a fluid pressure seal, wherein the annual region of relatively soft metal is welded onto the core of relatively hard metal.

11. (Once Amended) [The composite metal seal ring as claimed in claim 8] A composite metal seal ring for effecting a fluid pressure seal with respective annular surfaces of first and second hub members, the composite metal seal ring comprising an annular core of relatively hard metal, a first annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, and a second annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, the first annular region of relatively soft metal having a first annular surface for mating with the annular surface of the first hub member to effect a fluid pressure seal with the first hub member, and the second annular region of relatively soft metal having a second annular surface for mating with the annular surface of the second hub member to effect a fluid pressure seal with the second hub member, wherein the two annular regions of relatively soft metal are displaced from each other along a longitudinal axis of the composite metal seal ring, wherein the first annual region of relatively soft metal is welded onto the annular core of relatively hard metal, and the relatively soft metal of the second annular region of relatively soft metal is welded onto the annular core of relatively hard metal.

26. (Once Amended) [The composite metal seal ring as claimed in claim 21,] A composite metal seal ring for effecting a resettable fluid pressure seal with respective annular surfaces of first and second hub members, the composite metal seal ring comprising an annular core of relatively hard metal, a first annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, and a second annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, the first annular region of relatively soft metal having a first annular surface for mating with the annular surface of the first hub member to effect a fluid pressure seal with the first hub member, and the second annular region of relatively soft metal having a second annular surface for mating with the annular surface of the second hub member to effect a fluid pressure seal with the second hub member, wherein the two annular regions of relatively soft metal are displaced from each other along a longitudinal axis of the composite metal seal ring;

wherein the first annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch, and the second annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch;

wherein the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the first annular region of relatively soft metal, and the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the second annular region of relatively soft metal;

wherein the first annual region of relatively soft metal is welded onto the annular core of relatively hard metal, and the relatively soft metal of the second annular region of relatively soft metal is welded onto the annular core of relatively hard metal;

wherein the composite metal seal ring has a longitudinal axis, and the annular surface of the first annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the second annular region of relatively soft metal and that is largest toward the second annular region of relatively soft metal, and the annular surface of the second annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the first annular region of relatively soft metal and that is largest toward the first annular region of relatively soft metal; and

wherein the composite metal seal ring is adapted for containing a pressure within the hubs of at least 10,000 psi, the composite metal seal ring has an internal diameter of at least 3 inches, and the composite metal seal ring is a hybrid of a pressure energized seal type AX and a compression seal type BX.

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[illegible] Buddhist sect of the 7th century and later. [illegible]

bon·bon [illegible] (esp. collectively) -ol, (esp. [illegible]) -ols. any of [illegible], as Hydrocorpus bonaci. [illegible]

Bo·na De·a (bō′nä dē′ä), an ancient Roman goddess of chastity and fertility, worshiped by women and believed to be the wife, sister, or daughter of Faunus. Also called Fauna. [< L: lit., (the) Good Goddess]

Bon·a·dox·in (bon′ə dok′sin), n. *Pharm., Trademark.* [illegible]

bo·na fi·de (bō′nə fīd′, bon′ə; bō′nə fī′dē), *in good faith; without fraud.* [< L] —**bona-fide** (bō′nə fīd′, [illegible]), adj.

bo·na fi·des (bō′nə fī′dēz; *Eng.* bō′nə fī′dēz), *Latin.* [illegible]; absence of fraud or deceit; the state of being [illegible] claims or appearances indicate: *The bona fides of this contract is open to question.* Cf. mala fides.

Bon·aire (bō nâr′), n. an island in the E Netherlands Antilles in the S West Indies. 5614 (1960); 95 sq. mi.

bon a·mi (bôn na mē′), pl. **bons a·mis** (bôn za mē′). *French.* 1. a good friend. 2. a lover.

bo·nan·za (bə nan′zə, bō-), n. *U.S.* 1. a rich mass of ore, as found in mining. 2. a source of great and sudden wealth or luck; a spectacular windfall: *The play proved to be a bonanza for its lucky backers.* [< Sp: lit., smooth sea, hence, good luck, rich vein of ore] < popular var. [illegible]

Bo·na·parte (bō′nə pärt′; Fr. bô na part′), n. 1. Jé·rôme [illegible], 1784–1860, king of Westphalia 1807 (brother of Napoleon I). 2. **Jo·seph** (jō′zəf; Fr. zhô zef′), 1768–1844, king of Naples 1806–08; king of Spain 1808–13 (brother of Napoleon I). 3. **Lou·is** (lo͞o′ē; Fr. lwē; Du. lo͞o ē′), 1778–1846, king of Holland 1806–10 (brother of Napoleon I). 4. **Lou·is Na·po·lé·on** (lo͞o′ē nə pō′lē ən; Fr. lwē na pô lā ôn′). See **Napoleon III.** 5. **Lu·cien** (lo͞o′shən; Fr. ly syaN′), 1775–1840, Prince of Canino (brother of Napoleon I). 6. **Napoléon.** See **Napoleon I.** 7. **Napoléon.** See **Napoleon II.** Italian, **Buonaparte.** —**Bo′na·par′te·an,** *adj.*

Bo·na·part·ist (bō′nə pär′tist), n. an adherent of the Bonapartes or their policies. [earlier *Buonapartist*. See BONAPARTE, -IST] —**Bo′na·part′ism,** n.

bon ap·pé·tit (bô na pā tē′), *French.* (I wish you) a hearty appetite.

Bon·a·ven·tu·ra (bon′ə ven cho͝or′ə; *It.* bô′nä ven-to͞o′rä), n. a boy's given name.

bon·a·ven·ture (bon′ə ven′chər, bon′ə ven′-), n. 1. See **bonaventure mast.** 2. See **bonaventure mizzen** (def. 1). [< It *buonaventura*, lit., good luck. See BONUS, VENTURE]

Bon·a·ven·ture (bon′ə ven′chər), n. **Saint** ("the *Seraphic Doctor*"), 1221–74, Italian scholastic theologian. Also, **Bonaventura.**

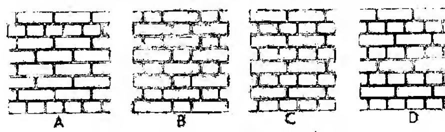
bon′aventure mast′, *Naut.* a mast fitted with a lateen sail or lugsail, situated behind the mizzenmast at or near the stern, used in the 16th and early 17th centuries. Also called **bonaventure, bonaventure mizzen.**

bon′aventure miz′zen, *Naut.* 1. Also called **bonaventure.** a lateen sail set on a bonaventure mast. 2. See **bonaventure mast.**

bon·a·vist (bon′ə vist), n. See **hyacinth bean.** [< It *buonavista* good sight. See BOON², VISTA]

bon·bon (bon′bon′; *Fr.* bôN bôN′), n., pl. **-bons** (-bonz′; *Fr.* -bôN′). 1. a fondant, fruit, or nut center dipped in fondant or chocolate; a chocolate. 2. a piece of confectionery; candy. [< F: lit., good-good; a repetitive compound, orig. nursery word]

bon·bon·nière (bôN bô nyer′), n., pl. **-nières** (-nyer′). 1. a confectioner's store. 2. (*italics*) *French.* a box or dish for candies. [< F: lit., candy-holder]



Bonds (def. 17a)
A, American bond; B, Flemish bond; C, English bond; D, English cross bond

bond¹ (bond), n. 1. something that binds, fastens, confines, or holds together. 2. a cord, rope, band, or ligament. 3. something that binds a person or persons to a certain line of behavior: *the bond of matrimony.* 4. something, as an agreement, friendship, etc., that unites individuals or peoples into a group; covenant: *the bond between nations.* 5. binding security; firm assurance: *My word is my bond.* 6. a sealed instrument under which a person, corporation, or government guarantees to pay a stated sum of money on or before a specified day. 7. any written obligation under seal. 8. *Law.* a written promise of a surety. 9. *Govt.* the state of dutiable goods on which the duties are unpaid, when stored under a bond in charge of the government: *goods in bond.* 10. Also called **bonded whiskey.** *U.S.* a whiskey that has been aged at least four years in a bonded warehouse before bottling. 11. *Finance.* a certificate of ownership of a specified portion of a debt due to be paid by a government or corporation to an individual holder and usually bearing a fixed rate of interest. 12. *Insurance.* **a.** a surety agreement. **b.** the money deposited, or the promissory arrangement entered into, under any such agreement. 13. a substance that causes particles to adhere; binder. 14. adhesion between two substances or objects, as concrete and reinforcing strands. 15. *Chem.* the attraction between atoms in a molecule. 16. See **bond paper.** 17. *Masonry.* **a.** any of various arrangements of bricks, stones, etc., having a regular pattern and intended to increase the strength or enhance the appearance of a construction. **b.** the overlap of bricks, stones, etc., in a construction so as to increase its strength. 18. *Elect.* an electric conductor placed between adjacent metal parts within a structure, as in a railroad track, aircraft, house, etc., to prevent the accumulation of static electricity. 19. *Obs.* bondsman. —*v.t.* 20. to put (goods, an employee, official, etc.) on or under bond: *The company refused to bond a former criminal.* 21. to connect or bind. 22. *Finance.* to place a bonded debt on or secure a debt by bonds; mortgage. 23. to join (two materials). 24. *Masonry.* to lay (bricks, stones, etc.) so as to produce a strong construction. 25. *Elect.* to provide with a bond: *to bond a railroad track.* —*v.i.* 26. to hold together or cohere, from or as from being bonded, as bricks in a wall or particles in a mass. [ME; var. of BAND²] —**bond′er,** n. —**bond′less,** *adj.*

—**Syn.** 1. bands, chains, fetters. 3. BOND, LINK, TIE agree in referring to a force or influence that unites people. BOND, however, usually emphasizes the strong and enduring quality of affection, whereas TIE may refer more esp. to duty, obligation, or responsibility: *bonds of memory; Blessed be the tie that binds; family ties.* A LINK is a definite connection, though a slighter one; it may indicate affection or merely some traceable influence or desultory communication: *a close link between friends.*

bond² (bond), *Obs.* —n. 1. a serf or slave. —*adj.* 2. in serfdom or slavery. [ME *bond(e)*, OE *bōnda* < Scand; cf. Icel *bōndi* HUSBAND(MAN), contr. of *būandi*, var. of *būande*, c. OE *būend* dweller, equiv. to *bū(an)* (to) dwell (see BOOR) + *-end* n. suffix, as in *fiend, friend*]

Bond (bond), n. **Car·rie** (kar′ē) (*nee Jacobs*) (jā′kəbz), 1862–1946, U.S. song writer and author.

Bond, G., a ring formation in the first quadrant of the face of the moon: about 12 miles in diameter.

Bond, W., a walled plain in the first quadrant of the face of the moon: about 100 miles in diameter.

bond·age (bon′dij), n. 1. slavery or involuntary servitude; serfdom. 2. the state of being bound by or subjected to external control. 3. *Early Eng. Law.* personal subjection to the control of a superior; villeinage. [ME < AL *bondagi(um)*. See BOND², -AGE]

—**Syn.** 1. captivity, restraint; prison. See **slavery.** 2. thralldom, captivity, confinement, imprisonment.

bond′ course′, *Masonry.* a course, as a heading course, for bonding masonry in depth.

bond·ed (bon′did), *adj.* 1. secured by or consisting of bonds: *bonded debt.* 2. placed in bond: *bonded goods.* [BOND¹ + -ED²]

bond′ed ware′house, a warehouse for goods held in bond by the government.

bond′ed whis′key, bond¹ (def. 10).

bond·hold·er (bond′hōl′dər), n. a holder of a bond or bonds issued by a government or corporation. [BOND¹ + HOLDER] —**bond′hold′ing,** *adj.*, n.

bond·maid (bond′mād′), n. 1. a female slave. 2. a female bound to service without wages. [BOND² + MAID]

bond·man (bond′mən), n., pl. **-men.** 1. a male slave. 2. a male bound to service without wages. 3. *Old Eng. Law.* a villein or other unfree tenant. Also, **bondsman.** [ME *bonde man.* See BOND², MAN¹]

bond′ pa′per, a superior variety of white paper, esp. used for stationery. Also called **bond.**

bond′ serv′ant, 1. one who serves in bondage; slave. 2. a person bound to service without wages. Also, **bond′-serv′ant.**

bonds·man¹ (bondz′mən), n., pl. **-men.** *Law.* one who is bound or who by bond becomes surety for another. [*bond's man* man of the bond, i.e., its signer; see BOND¹, MAN¹]

bonds·man² (bondz′mən), n., pl. **-men.** bondman. [ME *bondesman.* See BOND², MAN¹]

bond·stone (bond′stōn′), n. a stone, as a perpend, for bonding facing masonry to a masonry backing. [BOND¹ + STONE]

bonds·wom·an¹ (bondz′wo͝om′ən), n., pl. **-wom·en.** *Law.* a woman who is bound or who by bond becomes surety for another. [*bond's woman* woman of the bond, i.e., its signer; see BONDSMAN¹]

bonds·wom·an² (bondz′wo͝om′ən), n., pl. **-wom·en.** bondwoman. [BOND² + WOMAN]

bond·wom·an (bond′wo͝om′ən), n., pl. **-wom·en.** a female slave. [ME *bonde womman.* See BOND², WOMAN]

bone¹ (bōn), n., v., **boned, bon·ing.** —n. 1. *Anat., Zool.* **a.** one of the structures composing the skeleton of a vertebrate. **b.** the hard connective tissue forming the substance of the skeleton of most vertebrates. 2. such a structure from an edible animal, usually with meat adhering to it, as an article of food: *Pea soup should be made with a ham bone.* 3. any of various similarly hard or structural animal substances, as ivory, whalebone, etc. 4. something made of or resembling such a substance. 5. **bones, a.** the skeleton. **b.** a body: *Let his bones rest in peace.* **c.** *Games Slang.* dice. **d.** (*cap.*) See **Mr. Bones. e.** a simple rhythm instrument consisting of two, sometimes curved, bars or short strips of bone, ivory, wood, or the like, held between the fingers of one hand and clicked together. 6. a flat strip of whalebone or other material for stiffening corsets, petticoats, etc.; stay. 7. *Games Slang.* a domino. 8. **feel in one's bones,** *U.S.* to think or feel intuitively: *She felt in her bones that it was going to be a momentous day.* 9. **have a bone to pick with someone,** to have cause to disagree or argue with someone: *The teacher had a bone to pick with him because his homework paper was identical with his neighbor's.* 10. **make no bones about, a.** to deal with in a direct manner; act or speak openly. **b.** to have no fear of or objection to: *He makes no bones about helping his wife with the dishes.* —*v.t.* 11. to remove the bones from: *to bone a turkey.* 12. to put whalebone or another stiffener into (clothing). 13. *Agric.* to put bone meal into, as fertilizer. —*v.i.* 14. *Slang.* to study intensely; cram (often fol. by *up*): *She's boning up for her finals.* [ME *boon*, OE *bān*; c. D *been* bone, leg, Icel *bein* bone, G *Bein* leg] —**bone′less,** *adj.* —**bone′like′,** *adj.*

bone² (bōn), n. *Jazz.* a trombone. [short form]

Bône (bōn), n. a seaport in NE Algeria: site of Hippo Regius. 112,010 (1954). Also, **Bona.**

bone′ ash′, the remains of bones calcined in the air, used as a fertilizer and in the making of bone china. Also called **bone′ earth′.**

bone·black (bōn′blak′), n. a black, carbonaceous substance obtained by calcining bones in closed vessels, used as a black pigment, a decolorizing agent, etc. Also, **bone′ black′.** [BONE¹ + BLACK]

bone′ chi′na, a fine, naturally white china made with bone ash.

bone′ conduc′tion, *Med.* the transmission of sound vibrations to the internal ear through the cranial bones (opposed to *air conduction*).

boned (bōnd), *adj.* 1. having a particular kind of bone or bony structure (often used in combination): *beautifully boned; raw-boned; small-boned.* 2. having the bones taken out; cooked or served with the bones removed: *boned chicken; boned veal.* 3. braced or supported with stays, as a corset. 4. fertilized with bone: *boned land.* [BONE¹ + -ED³]

bone-dry (bōn′drī′), *adj.* 1. *Informal.* very dry or thirsty. 2. *Ceram.* (of clay) thoroughly dried.

bone·fish (bōn′fish′), n., pl. **-fish·es,** (esp. *collectively*) **-fish.** a marine game fish, *Albula vulpes*, found in shallow tropical waters, having a skeleton composed of numerous small, fine bones. Also called ladyfish. [BONE¹ + FISH]

bone·head (bōn′hed′), n. a stupid, obstinate person; blockhead. [BONE¹ + HEAD] —**bone′head′ed,** *adj.* —**bone′head′ed·ness,** n.

bone′ meal′, *Agric.* bones ground to a coarse powder, used as fertilizer or feed.

bone′ of conten′tion, the subject or focal point of a dispute: *The terms of the old man's will were a bone of contention to his survivors.*

bone′ oil′, a fetid, tarry liquid obtained in the dry distillation of bone.

Boneset, *Eupatorium perfoliatum* (Height 3 to 5 ft.)

bon·er¹ (bō′nər), n. one who or that which bones. [BONE¹ + -ER¹]

bon·er² (bō′nər), n. *Slang.* a foolish and obvious blunder. [BONE(HEAD) + -ER¹]

bone·set (bōn′set′), n. any plant of the genus *Eupatorium*, esp. *E. perfoliatum*, of North America, also called thoroughwort. [BONE¹ + SET (v.), so named (by inversion) because supposed to have healing properties]

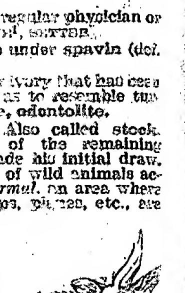
bone·set·ter (bōn′set′ər), n. one who treats or sets fractures, broken, or dislocated bones, or the like, esp. such a person who is not a regular physician or surgeon; healer. [late ME; see BONE¹, SETTER]

bone′ spav′in, *Vet. Pathol.* See under **spavin** (def. 1).

bone′ tur′quoise, fossil bone or ivory that has been colored naturally or artificially so as to resemble turquoise. Also called **fossil turquoise, odontolite.**

bone·yard (bōn′yärd′), n. 1. Also called **stock.** *Dominoes.* the bank, consisting of the remaining dominoes after each person has made his initial draw. 2. a place or area where the bones of wild animals accumulate or are collected. 3. *Informal.* an area where old, wrecked, or discarded cars, ships, planes, etc., are collected prior to being broken up for scrap or otherwise disposed of. [BONE¹ + YARD²]

bon·fire (bon′fīr′), n. 1. a large fire in the open air, for warmth, entertainment, or celebration, to burn leaves, garbage, etc., or as a signal. 2. any fire built in the open. [late ME *bone fire*, i.e., a fire with bones for fuel]



Bongo (4 ft. high at shoulder)

bon·go¹ (boŋ′gō, bôŋ′-), n., pl. **-gos,** (esp. *collectively*) **-go.** a reddish-brown antelope, *Taurotragus euryceros*, of the forests of tropical Africa, having white stripes and large, spirally twisted horns. [< an African language]

bon·go² (boŋ′gō, bôŋ′-), n., pl. **-gos, -goes.** one of a pair of small tuned drums, played by beating with the fingers. Also called **bon′go drum′.** [< Amer Sp *bongó*]

bon·grace (bon′grās′), n. *Naut.* bowgrace.

bon gré, mal gré (bôN′ grā′ mal′ grā′), *French.* whether willing or not; willy-nilly.

Bon·ham (bon′əm), n. a town in NE Texas. 7357 (1960).

Bon·heur (bo nûr′; *Fr.* bô nœr′), n. **Ro·sa** (rō′zə; *Fr.* rôz a′), (*Maria Rosalie Bonheur*), 1822–99, French painter.

bon·heur-du-jour (bə nûr′do͞o zho͝or′, -dyo͞o-; *Fr.* bô nœr dy zho͞or′), n., pl. **bon·heurs-du-jour** (bə-nûr′do͞o zho͝or′, -dyo͞o-; *Fr.* bô nœr dy zho͞or′). *French Furniture.* a dainty fall-front desk of the late 18th and early 19th centuries. [< F: lit., happiness of the day, from the favor it found in its time]

bon·ho·mie (bon′ə mē′; *Fr.* bô nô mē′), n. frank and simple good-heartedness; a good-natured manner. [< F, equiv. to *bonhomme* good-natured man (see BOON², HOMO) + -ie -Y³] —**bon·ho·mous** ([illegible]), *adj.*

Bon·homme Rich·ard (bon′om rich′ərd; *Fr.* bô-nôm′ rē shar′), the flagship of John Paul Jones.

Bon·i·face (bon′ə fās′; *for 4 also Fr.* bô nē fas′), n. 1. **Saint** (*Wynfrith*), A.D. 680?–755?, English monk who became a missionary in Germany. 2. a jovial innkeeper in *The Beaux' Stratagem.* 3. (*l.c.*) any landlord or innkeeper. 4. a boy's given name.

Boniface I, Saint, died A.D. 422, pope 418–422.

Boniface II, pope A.D. 530–532.

Boniface III, pope A.D. 607.

Boniface IV, Saint, pope A.D. 608–615.

Boniface V, died A.D. 625, pope 619–625.

Boniface VI, pope A.D. 896.

Boniface VII, antipope A.D. 974, 984–985.

Boniface VIII, (*Benedetto Caetani*) c1235–1303, Italian ecclesiastic: pope 1294–1303.

Boniface IX, (*Pietro Tomacelli*) died 1404, Italian ecclesiastic: pope 1389–1404.

Bon·ing·ton (bon′ing tən), n. **Richard Parkes** (pärks), 1801–28, English painter.

Bo′nin Is′lands (bō′nin), a group of islands in the N Pacific, SE of Japan: under U.S. military administration; uninhabited since World War II. [illegible] Japanese, **Ogasawara Jima.**

Bo·ni·ta (bə nē′tə, bō-), n. a girl's given name.

bo·ni·to (bə nē′tō), n., pl. [illegible] (esp. *collectively*) **-to,** (esp. referring to two or more kinds or species) **-tos.** 1. any mackerellike fish of the genus *Sarda*, as *S. sarda*, found [illegible]

SULT implies such insolence of speech or manner as deeply humiliates or wounds one's feelings and arouses to anger. INDIGNITY is especially used of inconsiderate, contemptuous treatment toward one entitled to respect. AFFRONT implies open disrespect or offense shown, as it were, to the face. SLIGHT may imply inadvertent indifference or disregard, which may also indicate ill-concealed contempt. —Ant. 1, 4. compliment.

in·sul·ta·tion (in′səl tā′shən), *n. Archaic.* insult. [< L *insultātiōn-* (s. of *insultātiō*), equiv. to *insultāt(us)* insulted (ptp. of *insultāre*) + *-iōn-* -ION]

in·sult·ing (in sul′ting), *adj.* tending to give or cause insult; characterized by rudeness, insolence, etc. [INSULT + -ING²]

in·su·per·a·ble (in sōō′pər ə bəl), *adj.* incapable of being passed over, overcome, or surmounted: *an insuperable barrier.* [ME < L *insuperābil(is).* See IN-³, SUPERABLE] —**in·su′per·a·bil′i·ty, in·su′per·a·ble·ness,** *n.* —**in·su′per·a·bly,** *adv.*

in·sup·port·a·ble (in′sə pōr′tə bəl, -pôr′-), *adj.* 1. not endurable; insufferable. 2. incapable of support, as by evidence or collected facts: *an insupportable accusation.* [< LL *insupportābil(is).* See IN-³, SUPPORTABLE] —**in′sup·port′a·ble·ness,** *n.* —**in′sup·port′a·bly,** *adv.*

in·sup·press·i·ble (in′sə pres′ə bəl), *adj.* incapable of being suppressed: *his insuppressible humor.* [IN-³ + SUPPRESSIBLE] —**in′sup·press′i·bly,** *adv.*

in·sur·a·ble (in shŏŏr′ə bəl), *adj.* capable of being insured, as against risk of loss or harm; proper to be insured. [INSURE + -ABLE] —**in·sur′a·bil′i·ty,** *n.*

in·sur·ance (in shŏŏr′əns), *n.* 1. the act, system, or business of insuring property, life, one's person, etc., against loss or harm arising in specified contingencies, as fire, accident, death, disablement, or the like, in consideration of a payment proportionate to the risk involved. 2. coverage by contract in which one party agrees to indemnify or reimburse another for any loss that occurs under the terms of the contract. 3. the contract itself, set forth in a written or printed agreement or policy. 4. the amount for which anything is insured. 5. *Rare.* an insurance premium. [INSURE + -ANCE]

in·sur·ant (in shŏŏr′ənt), *n. Rare.* a person who takes out an insurance policy. [INSURE + -ANT]

in·sure (in shŏŏr′), *v.*, **-sured, -sur·ing.** —*v.t.* 1. to guarantee against loss or harm. 2. to secure indemnity to or on, in case of loss, damage, or death. 3. to issue or procure an insurance policy on or for. 4. ensure (defs. 1–3). —*v.i.* 5. to issue or procure an insurance policy. [var. of ENSURE]
—**Syn.** 1. warrant. 4. assure.

in·sured (in shŏŏrd′), *n.* a person covered by an insurance policy. [INSURE + -ED²]

in·sur·er (in shŏŏr′ər), *n.* 1. *Insurance.* a person or company that contracts to indemnify another in the event of loss or damage. 2. one who or that which insures. [INSURE + -ER¹]

in·sur·gence (in sûr′jəns), *n.* an act of rebellion. [INSURG(ENT) + -ENCE]

in·sur·gen·cy (in sûr′jən sē), *n.* state or condition of being insurgent; insurrection against an existing government by a group not recognized as having the status of a belligerent; rebellion without a revolutionary government. [INSURGEN(T) + -CY]

in·sur·gent (in sûr′jənt), *n.* 1. a person who rises in forcible opposition to lawful authority, esp. one who engages in armed resistance to a government or to the execution of its laws; rebel. 2. *U.S. Politics.* a member of a section of a political party that revolts against the methods or policies of the party. —*adj.* 3. rising in revolt; rebellious. 4. surging or rushing in: *The insurgent waves battered the shore.* [< L *insurgent-* (s. of *insurgēns*) rising up against, prp. of *insurgere.* See IN-², SURGE, -ENT]

insur′ing clause′, the clause in an insurance policy setting forth the kind and degree of coverage granted by the insurer.

in·sur·mount·a·ble (in′sər moun′tə bəl), *adj.* incapable of being surmounted, passed over, or overcome: *an insurmountable obstacle.* [IN-³ + SURMOUNTABLE] —**in′sur·mount′a·bil′i·ty, in′sur·mount′a·ble·ness,** *n.* —**in′sur·mount′a·bly,** *adv.*

in·sur·rec·tion (in′sə rek′shən), *n.* 1. the act or an instance of rising in arms or open rebellion against civil authority or an established government. 2. any act or instance of revolt or open resistance to established authority. [late ME < LL *insurrectiōn-* (s. of *insurrectiō*), equiv. to *insurrect(us)* risen up against (ptp. of *insurgere*) + *-iōn-* -ION] —**in′sur·rec′tion·al,** *adj.* —**in′sur·rec′tion·al·ly,** *adv.* —**in′sur·rec′tion·ism,** *n.* —**in′sur·rec′tion·ist,** *n.*
—**Syn.** 1. insurgency, uprising. 2. mutiny. See **revolt.**

in·sur·rec·tion·ar·y (in′sə rek′shə ner′ē), *adj., n., pl.* **-ar·ies.** —*adj.* 1. of, pertaining to, or of the nature of insurrection. 2. given to or causing insurrection. —*n.* 3. a person who engages in insurrection; rebel; insurgent. [INSURRECTION + -ARY]

in·sur·rec·tion·ise (in′sə rek′shə nīz′), *v.t.*, **-ised, -is·ing.** *Chiefly Brit.* insurrectionize.

in·sur·rec·tion·ize (in′sə rek′shə nīz′), *v.t.*, **-ized, -iz·ing.** 1. to cause insurrection in (a country or the like). 2. to rouse (a person, group, or people) to insurgent action. [INSURRECTION + -IZE]

in·sus·cep·ti·ble (in′sə sep′tə bəl), *adj.* not susceptible; incapable of being influenced or affected (usually fol. by *of* or *to*): *insusceptible of flattery; insusceptible to infection.* [IN-³ + SUSCEPTIBLE] —**in′sus·cep′ti·bil′i·ty,** *n.* —**in′sus·cep′ti·bly,** *adv.*

in·swathe (in swāth′), *v.t.*, **-swathed, -swath·ing.** *Rare.* enswathe. —**in·swathe′ment,** *n.*

in·swept (in′swept′), *adj.* tapering at the front or tip, as an airplane wing. [adj. use of v. phrase *swept in*]

in·swing·er (in′swing′ər), *n. Cricket.* a bowled ball that veers from off side to leg side. Cf. **outswinger.** [IN + SWINGER]

int., 1. interest. 2. interim. 3. interior. 4. interjection. 5. internal. 6. international. 7. interpreter. 8. interval. 9. intransitive.

in·tact (in takt′), *adj.* 1. not altered, broken or impaired; remaining uninjured, sound, or whole: *The vase remained intact despite rough handling in shipment.* 2. not changed or diminished... emasculated. 4. having the hymen unbroken; virginal. [late ME < L *intact(us)* untouched, equiv. to *in-* IN-³ + *tactus,* ptp. of *tangere* to touch] —**in·tact′ly,** *adv.* —**in·tact′ness,** *n.*
—**Syn.** 1. See **complete.**

in·tagl·io (in tal′yō, -täl′-; *It.* ēn tä′lyō), *n., pl.* **-tagl·ios,** *It.* **-ta·gli** (-tä′lyē). 1. a gem, seal, piece of jewelry, or the like, cut with an incised or sunken design. 2. incised carving, as opposed to carving in relief. 3. ornamentation with a figure or design sunk below the surface. 4. an incised or countersunk die. 5. a figure or design so produced. 6. a process in which a design, text, etc., is engraved into the surface of a plate so that when ink is applied and the excess is wiped off, ink remains in the grooves and is transferred to paper in printing, as in engraving, drypoint, etching, etc. 7. an impression or printing from such a design, engraving, etc. [< It, deriv. of *intagliare* to cut in, engrave, equiv. to *in-* IN-² + *tagliare* to cut < LL *tāliāre;* deriv. of L *tālea* a cutting; see TALLY]

in·take (in′tāk′), *n.* 1. the point at which a fluid is taken into a channel, pipe, etc. 2. the act or an instance of taking in. 3. that which is taken in. 4. a quantity taken in: *the intake of oxygen.* 5. a narrowing; contraction. [n. use of v. phrase *take in*]

in·tan·gi·ble (in tan′jə bəl), *adj.* 1. not tangible; incapable of being perceived by the sense of touch, as incorporeal or immaterial things. 2. not definite or clear to the mind: *intangible arguments.* 3. (of an asset) existing only in connection with something else, as the good will of a business. —*n.* 4. something intangible, esp. an intangible asset. [< ML *intangibil(is).* See IN-³, TANGIBLE] —**in·tan′gi·bil′i·ty, in·tan′gi·ble·ness,** *n.* —**in·tan′gi·bly,** *adv.*

in·tar·si·a (in tär′sē ə), *n.* an art or technique of decorating a surface with inlaid patterns, esp. of wood mosaic, developed during the Renaissance. Also, **tarsia.** [IN-² + It. *tarsia* < Ar *tarṣī* an inlay] —**in·tar·si·ate** (in tär′sē āt′, -it), *adj.*

in·tar·sist (in tär′sist), *n.* a person who creates in or practices intarsia. [INTARS(IA) + -IST]

in·te·ger (in′ti jər), *n.* 1. one of the positive or negative numbers 1, 2, 3, etc., or 0; a whole number, as distinguished from a fraction or a mixed number. 2. a complete entity. [< L: untouched, hence, undivided, whole, equiv. to *in-* IN-³ + *-teg-* (var. of *tag-,* ptp. s. of *tangere* to touch) + *-er* adj. suffix]

in·te·ger vi·tae (in′te ger′ wē′tī; *Eng.* in′ti jər vī′tē), *Latin.* blameless in life; innocent. Horace, *Odes,* I.

in·te·gra·ble (in′tə grə bəl), *adj. Math.* capable of being integrated, as a mathematical function or differential equation. [INTEGR(ATE) + -ABLE] —**in′te·gra·bil′i·ty,** *n.*

in·te·gral (in′tə grəl), *adj.* 1. of, pertaining to, or belonging as a part of the whole; constituent or component: *the integral parts of the human body.* 2. necessary to the completeness of the whole: *This point is integral to his plan.* 3. made up of parts which together constitute a whole. 4. entire; complete; whole: *the integral works of a writer.* 5. *Arith.* pertaining to or being an integer; not fractional. 6. *Math.* pertaining to or involving integrals. —*n.* 7. an integral whole. 8. *Math.* **a.** Also called **Riemann integral.** the numerical measure of the area bounded above by the graph of a given function, below by the *x*-axis, and on the sides by ordinates drawn at the endpoints of a specified interval; the limit, as the norm of partitions of the given interval approaches zero, of the sum of the products of the function evaluated at a point in each subinterval times the length of the subinterval. **b.** a primitive. **c.** any of several analogous quantities. Cf. **improper integral, line integral, multiple integral, surface integral.** [< LL *integrāl(is).* See INTEGER, -AL¹] —**in·te·gral·i·ty** (in′tə gral′i tē), *n.* —**in′te·gral·ly,** *adv.*

in′tegral cal′culus, the branch of mathematics that deals with integrals, esp. the methods of ascertaining indefinite integrals and applying them to the solution of differential equations and the determining of areas, volumes, and lengths.

in′tegral curve′, *Math.* a curve that is a geometric representation of a functional solution to a given differential equation.

in′tegral domain′, *Math.* a commutative ring in which the cancellation law holds true. Also called **domain of integrity.**

in′tegral equa′tion, *Math.* an equation in which an integral involving a dependent variable appears.

in′tegral test′, *Math.* the theorem that a given infinite series converges if the function whose value at each integer is the corresponding term in the series is decreasing, tends to zero, and results in a finite number when integrated from one to infinity.

in·te·grand (in′tə grand′), *n. Math.* the expression to be integrated. [< L *integrand(um),* n. use of neut. of *integrandus,* ger. of *integrāre* to INTEGRATE]

in·te·grant (in′tə grənt), *adj.* 1. making up or being a part of a whole; constituent. —*n.* 2. an integrant part. 3. a solid, rigid sheet of building material composed of several layers of the same or of different materials. [< L *integrant-* (s. of *integrāns*) making whole, prp. of *integrāre.* See INTEGER, -ANT]

in·te·graph (in′tə graf′, -gräf′), *n.* integrator (def. 2). [b. INTEGRATE and -GRAPH]

in·te·grate (in′tə grāt′), *v.*, **-grat·ed, -grat·ing.** —*v.t.* 1. to bring together or incorporate (parts) into a whole. 2. to make up, combine, or complete to produce a whole or a larger unit, as parts do. 3. to unite or combine. 4. to indicate the total amount or the mean value of. 5. *Math.* to find the integral of. 6. *U.S.* **a.** to combine (educational facilities, classes, and the like, previously segregated by race) into one unified system. **b.** to give or cause to give equal opportunity to members of all races, religions, and ethnic groups, esp. to Negroes, to belong to, be employed by, be customers of, or vote in (an organization, place of business, city, State, etc.): *to integrate a restaurant; to integrate a country club.* **c.** to give or cause to give equal opportunity and consideration to (a racial, religious, or ethnic group or a member of such a group): *to integrate the Negroes in Mississippi.* —*v.i. U.S.* 6. (of a school, neighborhood, place of business, city, etc.) to become integrated. 7. (of a racial, religious, or ethnic group) ... to become integ...

in·te·grat·ed (in′tə grā′tid), *adj.* 1. having on a b... of equal membership individuals of different ra... religious, and ethnic groups: *an integrated school.* ... **segregated.** 2. combining or coordinating sepa... elements so as to provide a harmonious, interre... whole: *an integrated plot; an integrated course of study.* ... organized or structured so that constituent units fu... tion cooperatively: *an integrated economy.* 4. *Sociol.* ... or pertaining to a group or society whose member... teract on the basis of commonly held norms or val... 5. *Psychol.* characterized by integration. [INTEGRA... + -ED²]

in′tegrated bar′, *Law.* (in some States) a syst... of bar associations to which all lawyers are require... belong. Also called **incorporated bar.**

in′tegrated da′ta proc′essing, the proce... of information by systematic techniques which red... human intervention to a minimum and which emplo... language common to all the machines in the syst... *Abbr.:* IDP. Cf. **automatic data processing.**

in′tegrating fac′tor, *Math.* a factor that u... multiplying a differential equation with right-hand ... equal to zero makes the equation integrable, usually ... making the resulting expression an exact differential ... some function.

in·te·gra·tion (in′tə grā′shən), *n.* 1. the act or ... instance of combining into an integral whole. 2. ... havior, as of an individual, that is in harmony with ... environment. 3. *Psychol.* the organization of the c... stituent elements of the personality into a coordina... harmonious whole. 4. *Math.* the operation of find... the integral of a function or equation, esp. solvin... differential equation. 5. *U.S.* **a.** the combination ... educational and other public facilities, previously ... regated by race, into one unified system. **b.** the ac... an instance of integrating an organization, place ... business, city, etc. **c.** the act or an instance of integr... ing a racial, religious, or ethnic group. [INTEGRAT... -ION; cf. L *integrātiō* renewal]

integra′tion by parts′, a method of evalua... an integral by use of the formula, $\int u\,dv = uv - \int v\,du$ ...

in·te·gra·tion·ist (in′tə grā′shə nist), *n. U.S.* a p... son who works for or favors the integration of edu... tional and other public facilities. [INTEGRATION + -I...

in·te·gra·tor (in′tə grā′tər), *n.* 1. one who or th... which integrates. 2. an instrument for performi... numerical integrations. [INTEGRATE + -OR²]

in·teg·ri·ty (in teg′ri tē), *n.* 1. soundness of and ... herence to moral principle and character; uprightne... honesty. 2. the state of being whole, entire, or u... diminished: *to preserve the integrity of the empire.* 3. ... sound, unimpaired, or perfect condition: *the integrity* ... *the text; the integrity of a ship's hull.* [late ME *integr...* < L *integritās.* See INTEGER, -ITY]
—**Syn.** 1. rectitude, probity, virtue. See **honor.** —A... 1. dishonesty.

in·teg·u·ment (in teg′yə mənt), *n.* 1. a natural cov... ing, as a skin, shell, rind, etc. 2. any covering, coat... enclosure, etc. [< L *integument(um)* a covering, ... IN-², TEGUMENT]
—**Syn.** 1, 2. cortex. 2. involucre, involucrum, wrappi... cloak.

in·teg·u·men·ta·ry (in teg′yə men′tə rē), *adj.* ... pertaining to, or like an integument. [INTEGUMENT... -ARY]

in·tel·lect (in′tᵊlekt′), *n.* 1. the power or facult... the mind by which one knows or understands, as di... tinguished from that by which one feels and that ... which one wills; the understanding; the faculty of thin... ing and acquiring knowledge. 2. capacity for thinki... and acquiring knowledge, esp. of a high order; men... capacity. 3. a particular mind or intelligence, esp. o... high order. 4. a person possessing a great capacity ... thought and knowledge. 5. minds collectively, as o... number of persons, or the persons themselves. [ME ... L *intellect(us),* equiv. to *intellect-* (ptp. s. of *intelleger...* understand; see INTELLIGENT) + *-us* n. suffix]
—**Syn.** 1. reason, sense, common sense, brains, ... mind. —**Ant.** 1. inanity.

in·tel·lec·tion (in′tᵊlek′shən), *n.* 1. the action or p... cess of understanding; the exercise of the intellect. ... particular act of the intellect. 3. a conception or ide... the result of such an act. [late ME < ML *intellection...* of *intellectiō*). See INTELLECT, -ION]

in·tel·lec·tive (in′tᵊlek′tiv), *adj.* 1. having pow... understand; intelligent. 2. of or pertaining to th... tellect. [late ME < L *intellectīv(us).* See INTEL... -IVE] —**in′tel·lec′tive·ly,** *adv.*

in·tel·lec·tu·al (in′tᵊlek′chōō əl), *adj.* 1. appeali... or engaging the intellect: *intellectual pursuits.* 2. ... pertaining to the intellect or its use: *intellectual p...* 3. directed or inclined toward things that involv... intellect: *intellectual tastes.* 4. possessing or sho... intellect or mental capacity, esp. to a high degre... *intellectual person.* 5. guided or developed by or re... on the intellect rather than upon emotions or feeli... 6. characterized by or suggesting a predominance o... tellect: *an intellectual way of speaking.* —*n.* 7. a pe... of superior intellect. 8. a person who places a high v... on or pursues things of interest to the intellect or ... more complex forms and fields of knowledge, as aesth... or philosophical matters, esp. on an abstract and gene... level. 9. an extremely rational person; one who re... on intellect rather than on emotions or feelings. 10... person professionally engaged in mental labor, a... writer, teacher, etc., as distinguished from a ma... laborer or businessman. 11. **intellectuals,** *Arch...* the mental faculties. 12. **intellectuals,** *Obs.* th... pertaining to the intellect. [ME < L *intellectuāl...* equiv. to *intellectu(s)* INTELLECT + *-ālis* -AL¹] —**in′... lec′tu·al·ly,** *adv.* —**in′tel·lec′tu·al·ness,** *n.*
—**Syn.** 1, 2. mental. 4. See **intelligent.** —**Ant.** 1... animal, sensual.

in·tel·lec·tu·al·ise (in′tᵊlek′chōō ə līz′), *v.t.,* ... **-ised, -is·ing.** *Chiefly Brit.* intellectualize. —**in′... lec′tu·al·i·sa′tion,** *n.* —**in′tel·lec′tu·al·is′er,** *n.*

in·tel·lec·tu·al·ism (in′tᵊlek′chōō ə liz′əm), *n.* ... the exercise of the intellect. 2. devotion to intellec... pursuits. 3. excessive emphasis on abstract or intellec... al matters, esp. with a lack of proper consideration f...

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TABLE 28-16 Aluminum Alloys

AA designation	UNS	Composition, %*: Cr	Cu	Mg	Mn	Si	Other	Condition‡	Mechanical properties†: Yield strength, kip/in² (MPa)	Tensile strength, kip/in² (MPa)	Elongation in 2 in, %	Hardness' HB
Wrought												
1060	A91060						99.6 Al min.	0	4 (28)	10 (69)	43	19
1100	A91100		0.05–0.2				99.0 Al min.	0	5 (34)	13 (90)	45	23
2024	A92024	0.1	3.8–4.9	1.2–1.8	0.3–0.9	0.5		T4	47 (324)	68 (469)	19	120
3003	A93003		0.05–0.2		1.0–1.5	0.6		H14	21 (145)	22 (152)	16	40
5052	A95052	0.15–0.35	0.1	2.2–2.8	0.1			0	13 (90)	2.8 (193)	30	47
5083	A95083	0.05–0.25	0.1	4.0–4.9	0.4–1.0	0.4		0	21 (145)			
5086	A95086	0.05–0.25	0.1	3.5–4.5	0.2–0.7	0.4		0	17 (117)	38 (262)	30	
5154	A95154	0.05–0.35	0.1	3.1–3.9	0.1	0.25		0	17 (117)	35 (241)	27	58
6061	A96061	0.04–0.35	0.15–0.4	0.8–1.2	0.15	0.4–0.8		T6	40 (276)	45 (310)	17	95
6063	A96063	0.1	0.1	0.45–0.9	0.1	0.2–0.6		T6	31 (214)	35 (241)	18	73
7075	A97075	0.18–0.28	1.2–2.0	2.1–2.9	0.3	0.40	5.1–6.1 Zn	T6	73 (503)	63 (572)	11	150
Cast												
242.0	A02420	0.25	3.5–4.5	1.2–1.8	0.35	0.7	1.7–2.3 Ni	S-T571		29 (200)		
295.0	A02950		4.0–5.0	0.03	0.35	0.7–1.5		S-T4		29 (200)	6	
A332.0	A13320		0.5–1.5	0.7–1.3	0.35	11–13	2.0–3.0 Ni	P-T551		31 (214)		
B443.0	A24430		0.15	0.05	0.35	4.5–6.0		S-F		17 (117)	3	
514.0	A05140		0.15	3.5–4.5	0.35	0.35		S-F		22 (152)	6	
520.0	A05200		0.25	9.5–10.6	0.15	0.25		S-T4	22 (152)	42 (290)	12	

*Single values are maximum values.
†Typical room-temperature properties.
‡S = sand-cast; P = permanent-mold-cast; other = temper designations.
SOURCE: Aluminum Association. Courtesy of National Association of Corrosion Engineers. To convert MPa to lbf/in², multiply by 145.04.

or plastic. This membrane functions as a barrier to protect the substrate from corrosion damage. A special prestressed-brick design that maintains the brick in compression by using a controlled-expansion resinous mortar and brick bedding material precludes the use of an elastomeric membrane.

Cement and Concrete Concrete is an aggregate of inert reinforcing particles in an amorphous matrix of hardened cement paste. Concrete made of portland cement has limited resistance to acids and bases and will fail mechanically following absorption of crystal-forming solutions such as brines and various organics. Concretes made of corrosion-resistant cements (such as calcium aluminate) can be selected for specific chemical exposures.

Soil Clay is the primary construction material for settling basins and waste-treatment evaporation ponds. Since there is no single type of clay even within a given geographical area, shrinkage, porosity, absorption characteristics, and chemical resistance must be checked for each application.

ORGANIC NONMETALLICS

Plastic Materials In comparison with metallic materials, the use of plastics is limited to relatively moderate temperatures and pressures [230°C (450°F) is considered high for plastics]. Plastics are also less resistant to mechanical abuse and have high expansion rates, low strengths (thermoplastics), and only fair resistance to solvents. However, they are lightweight, are good thermal and electrical insulators, are easy to fabricate and install, and have low friction factors.

Generally, plastics have excellent resistance to weak mineral acids and are unaffected by inorganic salt solutions—areas where metals are not entirely suitable. Since plastics do not corrode in the electrochemical sense, they offer another advantage over metals: most metals are affected by slight changes in pH, or minor impurities, or oxygen content, while plastics will remain resistant to these same changes.

The important thermoplastics used commercially are polyethylene, acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), cellulose acetate butyrate (CAB), vinylidene chloride (Saran), fluorocarbons (Teflon, Halar, Kel-F, Kynar), polycarbonates, polypropylene, nylons, and acetals (Delrin). Important thermosetting plastics are general-purpose polyester glass reinforced, bisphenol-based polyester glass, epoxy glass, vinyl ester glass, furan and phenolic glass, and asbestos reinforced.

THERMOPLASTICS

The most chemical-resistant plastic commercially available today is **tetrafluoroethylene** or **TFE** (Teflon). This thermoplastic is practically unaffected by all alkalies and acids except fluorine and chlorine gas at elevated temperatures and molten metals. It retains its properties up to 260°C (500°F). **Chlorotrifluoroethylene** or **CTFE** (Kel-F, Plaskon) also possesses excellent corrosion resistance to almost all acids and alkalies up to 180°C (350°F). A Teflon derivative has been developed from the copolymerization of tetrafluoroethylene and hexafluoropropylene. This resin, **FEP**, has similar properties to TFE except that it is not recommended for continuous exposures at temperatures above 200°C (400°F). Also, FEP can be extruded on conventional extrusion equipment, while TFE parts must be made by complicated powder-metallurgy techniques. Another version is **polyvinylidene fluoride,** or **PVF_2** (Kynar), which has excellent resistance to alkalies and acids to 150°C (300°F). It can be extruded. A more recent development is a copolymer of CTFE and ethylene (Halar). This material has excellent resistance to strong inorganic acids, bases, and salts up to 150°C. It also can be extruded.

Perfluoroalkoxy, or **PFA** (Teflon), has the general properties and chemical resistance of FEP at a temperature approaching 300°C (600°F).

Polyethylene is the lowest-cost plastic commercially available. Mechanical properties are generally poor, particularly above 50°C (120°F), and pipe must be fully supported. Carbon-filled grades are resistant to sunlight and weathering.

Unplasticized polyvinyl chlorides (type I) have excellent resistance to oxidizing acids other than concentrated and to most nonoxidizing acids. Resistance is good to weak and strong alkaline materials. Resistance to chlorinated hydrocarbons is not good. Polyvinylidene chloride, known as **Saran,** has good resistance to chlorinated hydrocarbons.

Acrylonitrile butadiene styrene (**ABS**) polymers have good resistance to nonoxidizing and weak acids but are not satisfactory with oxidizing acids. The upper temperature limit is about 65°C (150°F).

TABLE 28-19 Miscellaneous Alloys*

Alloy	Designation	UNS	Composition, %‡	Condition	Mechanical properties† Yield strength, kip/in² (MPa)	Tensile strength, kip/in² (MPa)	Elongation, %	Hardness, HB
Refractory alloys								
Niobium R04210 (columbium)		204–210	99.6 Cb	Annealed	37 (255)	53 (365)	26	80
Molybdenum		R03600	0.01–0.04 C					
Molybdenum, low C		R03650	0.01 C					
Molybdenum alloy		R03630	0.01–0.04 C, 0.40–0.55 Ti, 0.06–0.12 Zn					
Tantalum		R05200	99.8 min. Ta	Annealed		50 (345)	40	45
Tungsten		R07030	99.9 min. W	Annealed		270 (1862)		
Zirconium		R60702	4.5 Hf, 0.2 Fe + Cr, 99.2 Zi + Hf	Annealed	16 (110)	36 (248)	31	77
Precious metals and alloys								
Gold		P00020	99.95 min. Au	Annealed		19 (131)	45	25
Silver		P07015	99.95 min. Ag	Annealed	8 (55)	18 (124)	54	27
Sterling silver			7.5 Cu, 92.5 Ag	Annealed	20 (138)	41 (283)	26	65
Platinum		P04955	99.95 min. Pt	Annealed		18 (124)	38	39
Palladium		P03980	99.80 min. Pd	Annealed		25 (172)	27	38
Lead alloys								
Chemical lead			99.9 min. Pb	Rolled	1.9 (13)	2.5 (17)	50	5
Antimonial lead			90 Pb, 10 Sb	Rolled		4.1 (28)	47	13
Tellurium lead			99.85 Pb, 0.04 Te, 0.06 Cu	Rolled	2.2 (15)	3 (21)	45	6
50-50 solder		L05500	50 Pb, 50 Sn, 0.12 max. Sb	Cast		6.8 (47)	50	14
Magnesium alloys								
Wrought alloy	AZ31B	M11311	2.5–3.5 Al, 0.20 min. Mn, 0.6–1.4 Zn	Annealed	15–18 (103–124)	32 (220)	9–12	56
Cast alloy	AZ91C	M11914	8.1–9.3 Al, 0.13 min. Mn, 0.4–1.0 Zn	As cast	11 (76)	23 (159)		60
Cast alloy	EZ33A	M12330	2.0–3.1 Zn, 0.5–1.0 Zr	Aged	14 (97)	20 (138)	2	50
Wrought alloy	HK31A	M13310	0.3 Zn, 2.5–4.0 Th, 0.4–1.0 Zr	Stress hard-annealed	24–26 (165–179)	33–34 (228–234)	4	57
Titanium alloys								
Commercial pure	Gr. 1	R50250	0.20 Fe, 0.18 O	Annealed	35 (241)	48 (331)	30	120
Commercial pure	Gr. 2	R50400	0.30 Fe, 0.25 O	Annealed	50 (345)	63 (434)	28	200
Ti-Pd	Gr. 7	R52400	0.30 Fe, 0.25 O, 0.12–0.25 Pd	Annealed	50 (345)	63 (434)	28	200
Ti-6Al-4V	Gr. 5	R56400	5.5–5.6 Al, 0.40 Fe, 0.20 O, 3.5–4.5 V	Annealed	134 (924)	144 (993)	14	330
Low alloy	Gr. 12		0.2–0.4 Mo, 0.6–0.9 Ni	Annealed	65 (448)	75 (517)	25	
Cobalt alloys								
	N-155	R30155	0.08–0.16 C, 0.75–1.25 Cb, 18.50–21.0 Co, 20.0–22.5 Cr, 1.0–2.0 Mn, 2.5–3.5 Mo, 19–21 Ni, 1.0 Si, 2.0–3.0 W					
	MP35N	R30036	0.025 C, 19–21 Cr, 1.0 Fe, 0.15 Mn, 9.0–10.5 Mo, 33.37 Ni, 0.15 Si, 1.0 Ti	Annealed	60 (414)	135 (931)	70	
	Stelite 6	R30006	0.9–1.4 C, 27–31 Cr, 3 Fe, 1.0 Mn, 1.5 Mo, 3.0 Ni, 1.5 Si, 3.5–5.5 W	As cast		105 (724)	1	

*Courtesy of National Association of Corrosion Engineers. To convert MPa to lbf/in², multiply by 145.04.
†Typical room-temperature properties.
‡Single values are maximum values unless otherwise noted.